Section 9
COMPOSITE MOISTURE STABILITY CHART

The composite moisture stability chart (Figure 9-1) is a chart composed of four panels which depict stability, precipitable water, freezing level, and average relative humidity conditions. This computer-generated chart contains information obtained from upper-air observation data and is available twice daily with valid times of 00Z and 12Z.

The availability of upper-air data for analysis (on all panels) is indicated by the shape of the station symbols. Use the legend on the precipitable water panel (Figure 9-3) for the explanation of symbols common to all four panels. Mandatory levels referred to in the legend are the routinely used levels of surface; 1,000; 925; 850; 700; and 500 mb (hPa). Significant levels are nonroutine levels at which significant changes occur in the vertical profile of atmospheric properties during each observation.

STABILITY PANEL

The stability panel (Figure 9-2) is the upper left panel of the composite moisture stability chart. This panel contains two indexes that characterize the moisture and stability of the air. These indexes are the K index (KI) and the lifted index (LI).

K INDEX (KI)

The K index (KI) provides moisture and stability information. KI values range from high positive values to low negative values. A high positive KI implies moist and unstable air. A low or negative KI implies dry and stable air. KIs are considered high when values are at and above +20 and low when values are less than +20.

The KI is calculated by the summation of three terms:

KI = (850 mb/hPa temp - 500 mb/hPa temp)
+ (850 Mb/hPa dew point)
- (700 mb/hPa temp/dew point spread)

The first term (850 mb/hPa temp - 500 mb/hPa temp) describes the vertical temperature profile. The term compares the temperature at about 5,000 feet mean sea level (MSL) with the temperature at about 18,000 feet MSL. The larger the temperature difference, the less stable the air, and the higher the KI. The smaller the temperature difference, the more stable the air, and the lower the KI.

The second term, 850 mb (hPa) dew point, is a measure of the quantity of low-level moisture. The higher the dew point, the higher the moisture, and the higher the KI. The lower the dew point, the lower the moisture, and the lower the KI.

The third term, 700 mb (hPa) temp/dew point spread, is a measure of the level of saturation at 700 mb (hPa). The smaller the spread, the higher the level of saturation, and the higher the KI. The greater the spread, the lower the level of saturation (drier air), and the lower the KI.

The KI can change significantly over a short time period of time due to temperature and moisture changes.

LIFTED INDEX (LI)

The lifted index (LI) is a common measure of atmospheric stability. The LI is obtained by hypothetically displacing a surface parcel upward to 500 mb (hPa) (about 18,000 feet MSL) and evaluating its stability at that level. A surface parcel is a small sample of air with representative surface temperature and moisture conditions. As the parcel is "lifted" it cools due to expansion. The temperature the parcel would have at 500 mb (hPa) is then subtracted from the actual (observed) 500 mb (hPa) temperature. This difference is the LI. LI values can be positive, negative, or zero. The LI does not identify the parcel's stability behavior at any of the intermediate altitudes between the surface and 500 mb (hPa).

A positive LI means a lifted surface parcel of air is stable. With a positive LI, the parcel would be colder and more dense than the surrounding air at 500 mb (hPa). A more dense parcel would resist upward motion. The stable surface parcel is like a rock at the bottom of a pool which, being more dense than the water, would resist being displaced upward. The more positive the LI, the more stable the air. Large positive values (+8 or greater) would indicate very stable air.

A negative LI means a lifted surface parcel of air is unstable. With a negative LI, the parcel would be warmer and less dense than the surrounding air at 500 mb (hPa). A parcel which is less dense than the surrounding air would continue to rise and possibly gain increasing upward speed until stabilizing at some higher altitude. The unstable surface parcel is like a cork at the bottom of a pool which, being less dense than the water, would accelerate upward to the surface of the pool. Large negative values (-6 or less) would indicate very unstable air.

A zero LI means a lifted surface parcel of air is neutrally stable. With a zero LI, the lifted parcel would have the same temperature and density as the air at 500 mb (hPa) and have a tendency to neither rise or sink. A neutrally stable parcel offers no resistance to vertical motion and, without further influence, would remain at the displaced level.

Temperature and moisture changes in the atmosphere change lifted index values. LIs decrease (become less stable) by increasing the surface temperatures, increasing surface dew points (moisture), and/or decreasing 500 mb (hPa) temperatures. Cold lows and troughs aloft with warm humid surface conditions tend to be associated with unstable air. LIs increase (become more stable) by decreasing surface temperatures, decreasing surface dew points, and/or increasing 500 mb (hPa) temperatures. Warm highs and ridges aloft with cool, dry surface conditions tend to be associated with stable air. Note that the LI can change considerably just by daytime heating and nighttime cooling of surface air. Daytime heating will decrease the LI, and nighttime cooling will increase the LI.

PLOTTED DATA

Figure 9-2 shows the two stability indexes that are computed for each upper-air station. The LI is plotted above the station symbol, and the KI is plotted below the symbol. Station circles are blackened for LI values of zero or less. An "M" indicates the value is missing

STABILITY ANALYSIS

The analysis is based on the LI only and highlights weakly stable and unstable areas. Solid lines are drawn for values of +4 and less at intervals of 4 (+4, 0, -4, -8, etc.).

USING THE PANEL

The KI and LI can be used in combination to assess moisture and stability properties of air masses. Air masses can be classified as moist and stable, moist and unstable, dry and stable, and dry and unstable. When used in combination, the KI, although containing stability information, is used primarily to classify moisture information, and the LI primarily to classify stability information. See Figure 9-2. Aberdeen, SD, has air characterized as dry and stable. The KI is 3 (dry) and the LI is 19 (stable). Melbourne, FL, is an example of dry and unstable air. The KI is 8 (dry) and the LI is -1 (unstable). Moist and unstable air is depicted at Key West, FL. The KI is 29 (moist) and the LI is -3 (unstable). The last example, Albany, NY, indicates moist and stable air. The KI is 31 (moist) and the LI is 15 (stable).

Moisture and stability properties of air masses characterize the weather. High KIs are associated with the potential for clouds and precipitation. Weather associated with high LIs and stable air are stratiform clouds and steady precipitation. Weather associated with low and negative LIs are unstable air, convective clouds, and showery precipitation.

The KI and LI can also be used to evaluate thunderstorm information. The KI is an indicator of the probability of thunderstorms (Table 9-1). Higher KIs imply higher probabilities. Lower KIs imply lower probabilities. The low and negative LIs are indicators of intensities of thunderstorms, if they occur. Higher negative LIs imply greater instability and stronger updrafts in thunderstorms. High positive LIs suggest little, if any, chance of thunderstorms.

Air masses classified with negative LIs do not always contain thunderstorms. This can occur for several reasons. Thunderstorm development is inhibited when a layer of stable air is located between the surface and 500 mb (hPa). This stable layer is referred to as a "cap." Inadequate amounts of moisture may also limit thunderstorm development in the presence of negative LIs. It is also possible to have a positive LI and still have thunderstorms develop. This can happen when a layer of air aloft located above stable surface air, such as above a front, is unstable and is sufficiently lifted, or if temperature and moisture conditions change rapidly and stabilities decrease.

Seasons affect the use of the KI regarding thunderstorm information. During the warmer seasons of spring, summer, and fall, a high KI generally indicates conditions are favorable for thunderstorms (Table 9-1). During winter with cold temperatures, fairly high values do not necessarily mean conditions are favorable for thunderstorms. Cold 850 mb (hPa) temperatures mean low dew points (low moisture.) The temperature profile term can generate high KI values, but low dew points may mean inadequate moisture to support thunderstorm development.

Table 9-1 Thunderstorm Potential

Lifted Index (LI)	Severe Potential
0 to -2	Weak
-2 to -6	Moderate
≤ -6	Strong

K Index (KI)	Thunderstorm Probability
< 15	near 0%
15 - 19	20%
20 - 25	21% - 40%
26 - 30	41% - 60%
31 - 35	61% - 80%
36 - 40	81% - 90%
> 40	near 100%

PRECIPITABLE WATER PANEL

The precipitable water panel (Figure 9-3) is the upper right panel of the composite moisture stability chart. This panel is an analysis of the quantity of water vapor in the atmosphere from the surface to the 500 mb (hPa) level (18,000 feet MSL). The quantity of water vapor is shown as precipitable water, which is the amount of liquid water that would result if all the water vapor were condensed.

Two constant factors affect precipitable water reports. Warm air is capable of holding higher quantities of water vapor than cold air. Therefore, warm air masses generally have more precipitable water than cold air masses. For example, precipitable water values are higher during summer months than during winter months. Also, high elevation stations have smaller vertical columns of air between surface and 500 mb (hPa) than low elevation stations. Therefore, higher elevation stations tend to have lower precipitable water than lower stations.

PLOTTED DATA

Precipitable water values are plotted above each station symbol to the nearest hundredth of an inch. The percent relative to normal for the month is plotted below the station symbol. Blackened circles indicate stations with precipitable water values of 1.00 inch or more. An "M" plotted above the station symbol indicates missing data.

ANALYSIS

Isopleths (lines of equal values) of precipitable water are drawn and labeled for every 0.25 inches with heavier isopleths drawn at 0.50-inch intervals.

USING THE CHART

This panel is used to determine the quantity of water vapor in the air between the surface and 500 mb (hPa) (18,000 feet MSL). Higher moisture content indicates "more fuel" for convective conditions. In Figure 9-3, Glasgow, MT, has a plot of ".22/100." This indicates that 22 hundreds of an inch of precipitable water is present, which is the average for the month. At Oklahoma City, OK, the ".72/196" indicates that 72 hundredths of an inch of precipitable water is present, which is 196 percent of normal (about double) for any day during this month. At Aberdeen, SD, the percent of normal value is not plotted due to insufficient climatological data.

FREEZING LEVEL PANEL

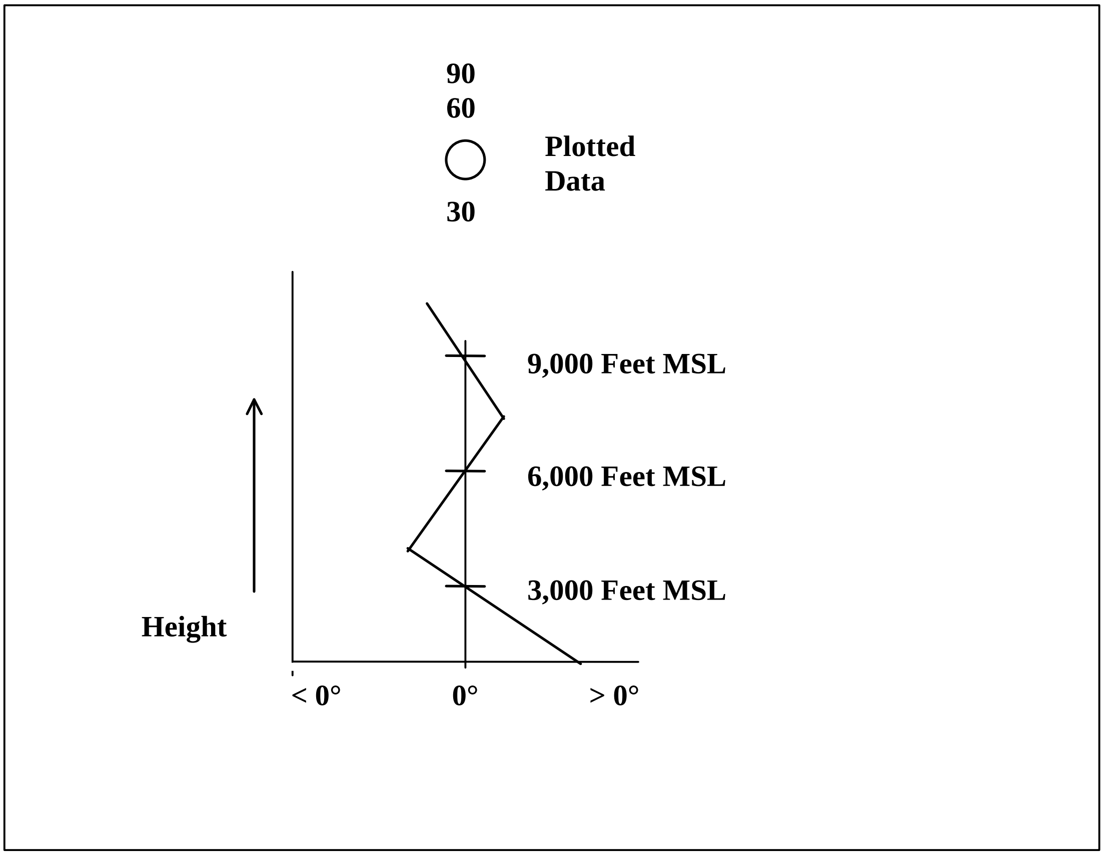
The freezing level panel (Figure 9-4) is the lower left panel of the composite moisture stability chart. This panel is an analysis of observed freezing levels. The freezing level is the height above MSL at which the temperature is zero degrees Celsius.

Freezing levels are affected by air mass temperatures. Colder air masses have lower freezing levels, and warmer air masses have higher freezing levels. Freezing levels change with the movement of contrasting cold and warm air masses. For example, freezing levels tend to lower behind cold fronts and rise ahead of warm fronts.

Generally, a station has one freezing level. Relative to the freezing level, the lower levels have above-freezing temperatures, and the upper levels have below-freezing temperatures. During very cold periods, all temperatures over a station may be below freezing and there would be no freezing level.

During colder periods of the year, and with certain weather systems such as fronts, stations may have more than one freezing level. There would be several layers of air with alternating above-freezing and below-freezing temperatures. A report from such a station would contain multiple freezing levels. Table 9-2 illustrates a vertical temperature profile drawn relative to zero degrees Celsius which contains multiple freezing levels. In this table there are two layers with above-freezing temperatures and two layers with below-freezing temperatures. Above-freezing layers extend from the surface to 3,000 feet MSL and from 6,000 to 9,000 feet MSL. Below-freezing layers extend from 3,000 to 6,000 feet MSL and above 9,000 feet MSL.

Table 9-2 Vertical Temperature Profile with Freezing Levels



PLOTTED DATA

Observed freezing levels are plotted on the chart in hundreds of feet MSL. Multiple freezing level events have plots for each freezing level. BF is plotted on the chart to indicate below-freezing temperatures at the surface. "M" indicates missing data. Note in Table 9-2 the freezing level plots associated with the illustrated vertical temperature profile. Table 9-3 provides examples of several station plots for various types of freezing level conditions.

ANALYSIS

Freezing levels are analyzed with contours (lines of constant height) and are drawn as solid lines. The lines are drawn with intervals of 4,000 feet beginning with 4,000 feet. Multiple freezing levels are analyzed for the lowest freezing level. Contours are labeled in hundreds of feet MSL. The surface freezing level is drawn and labeled as the 32-degree Fahrenheit (0° C)isotherm. The surface freezing level line encloses stations with BF data plots.

USING THE PANEL

The freezing level chart is used to assess freezing level heights and their values relative to flight profiles. In Figure 9-4, Salt Lake City, UT, is an example where all temperatures above the station were below freezing (below 0° C or 32° F.) Lake Charles, LA, depicts a single freezing level at 11,500 feet MSL. North Platte, NE, is an example of multiple freezing levels. The temperatures were below freezing at the surface but warmed to above freezing between 4,400 and 6,100 feet MSL. Above 6,100 feet MSL the temperatures were again below freezing.

In areas with single freezing levels, flights above the freezing level will be in below-freezing temperatures, and flights below the freezing level will be in above-freezing temperatures. In areas with multiple freezing levels, there are multiple layers of above- and below-freezing temperatures. According to Figure 9-4, a flight en route from Seattle, WA, to Portland, OR, at 7,000 feet would be flying above the freezing level and in below-freezing temperatures. A flight en route at 7,000 feet from Atlanta, GA, to Washington, DC, would be flying below the freezing level and in above-freezing temperatures.

Special care must be exercised to properly identify the altitudes of layers with above and below freezing temperatures when there is a potential for icing conditions.

Table 9-3 Plotting Freezing Levels

Plotted	Interpretation
○ BF	Entire observation is below freezing (0 degrees Celsius).
28 ╳	Freezing level is at 2,800 feet MSL; temperatures below freezing above 2,800 feet MSL. All significant levels are missing.
120 □	Freezing level at 12,000 feet; temperatures above 12,000 feet are below freezing. Some mandatory levels are missing.
110 51 ○ BF	Temperatures are below freezing from the surface to 5,100 feet; above freezing from 5,100 to 11,000 feet MSL; and below freezing above 11,000 feet MSL.
90 34 ○ 3	Lowest freezing level is at 300 feet; below freezing from 300 feet to 3,400 feet; above freezing from 3,400 to 9,000 feet; and below freezing above 9,000 feet.
M ○	Data is missing.

AVERAGE RELATIVE HUMIDITY PANEL

The average relative humidity panel (Figure 9-5) is the lower right panel of the composite moisture stability chart. This panel is an analysis of the average relative humidity for the layer surface to 500 mb (hPa).

Relative humidity is the ratio of the quantity of water vapor in a sample of air compared to the air's capacity to hold water vapor expressed in percent. The air's capacity to hold water vapor depends primarily on its temperature and, to a lesser extent, its pressure. Warm air can hold more water vapor than cold air. Air at lower pressure can hold more water vapor than air at higher pressure.

Average relative humidities of the layer are changed primarily by vertical motion of air. Upward motion increases relative humidities, and downward motion decreases relative humidities.

Relative humidity is an indicator of the degree to which air is saturated. Air is saturated when it contains all of the water vapor it can hold. High relative humidities (moist air) identify air which is at or close to saturation. Air with high relative humidites often contain clouds and may produce precipitation. Low relative humidities (dry air) identify air that is not close to saturation. Low relative humidity air tends to be free of clouds.

PLOTTED DATA

The average relative humidity is plotted above each station symbol. Blackened circles indicate stations with humidities of 50 percent and higher. An “M” indicates the value is missing.

ANALYSIS

Isopleths of relative humidity, called isohumes, are drawn and labeled every 10 percent, with more heavily shaded isohumes drawn for values of 10, 50, and 90 percent.

USING THE PANEL

This panel is used to determine the average relative humidity of air from the surface to 500 mb (hPa). Areas with high average relative humidities have a higher probability of thick clouds and possibly precipitation. Areas with low average relative humidities have a lower probability of thick clouds, although shallow cloud layers may be present. Weather-producing systems, such as lows and fronts, which are moving into areas with high average relative humidities have a high probability of developing clouds and precipitation. Significant values of average relative humidities which support the possibility of developing clouds and precipitation are 50% and higher with unstable air, and 70% and higher for stable air. Weather-producing systems affecting areas with low average relative humidities, 30% and less, may produce only a few clouds, if any. According to Figure 9-5, much of Arkansas has very moist air with average relative humidities greater than 90%, while western Arizona has dry air with average relative humidities less than 30%.

High values of relative humidity do not necessarily mean high values of water vapor content (precipitable water). For example in Figure 9-3, Oakland, CA, had less water vapor content than Miami, FL (.64 and 1.43 respectively). However, in Figure 9-5, the average relative humidities are the same for both stations. If rain were falling at both stations, the result would likely be lighter precipitation totals for Oakland.

USING THE CHART

This chart is used to identify the distribution of moisture, stability, and freezing level properties of the atmosphere. These properties and their association with weather systems provide important insights into existing and forecast weather conditions as well as possible aviation weather hazards.

Generally these properties tend to move with the associated weather systems, such as lows, highs, and fronts. Contrasting property values within weather systems are redistributed relative to the systems by advecting winds. Also, changes in property values relative to the systems can occur as a result of development and dissipation processes. In some instances property values will remain stationary relative to geographical features, such as mountains and coastal regions.

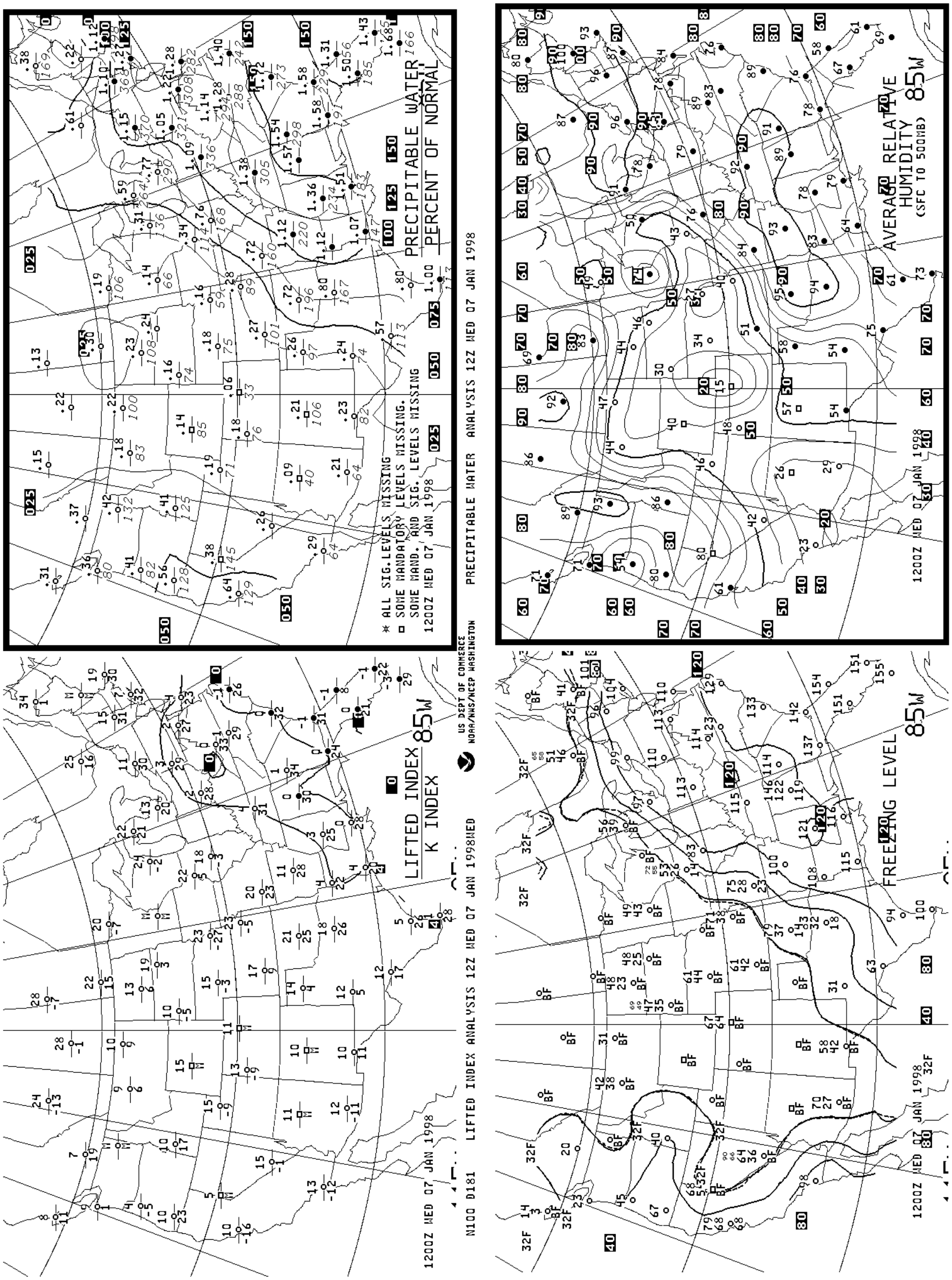


Figure 9-1. Composite Moisture Stability Chart.

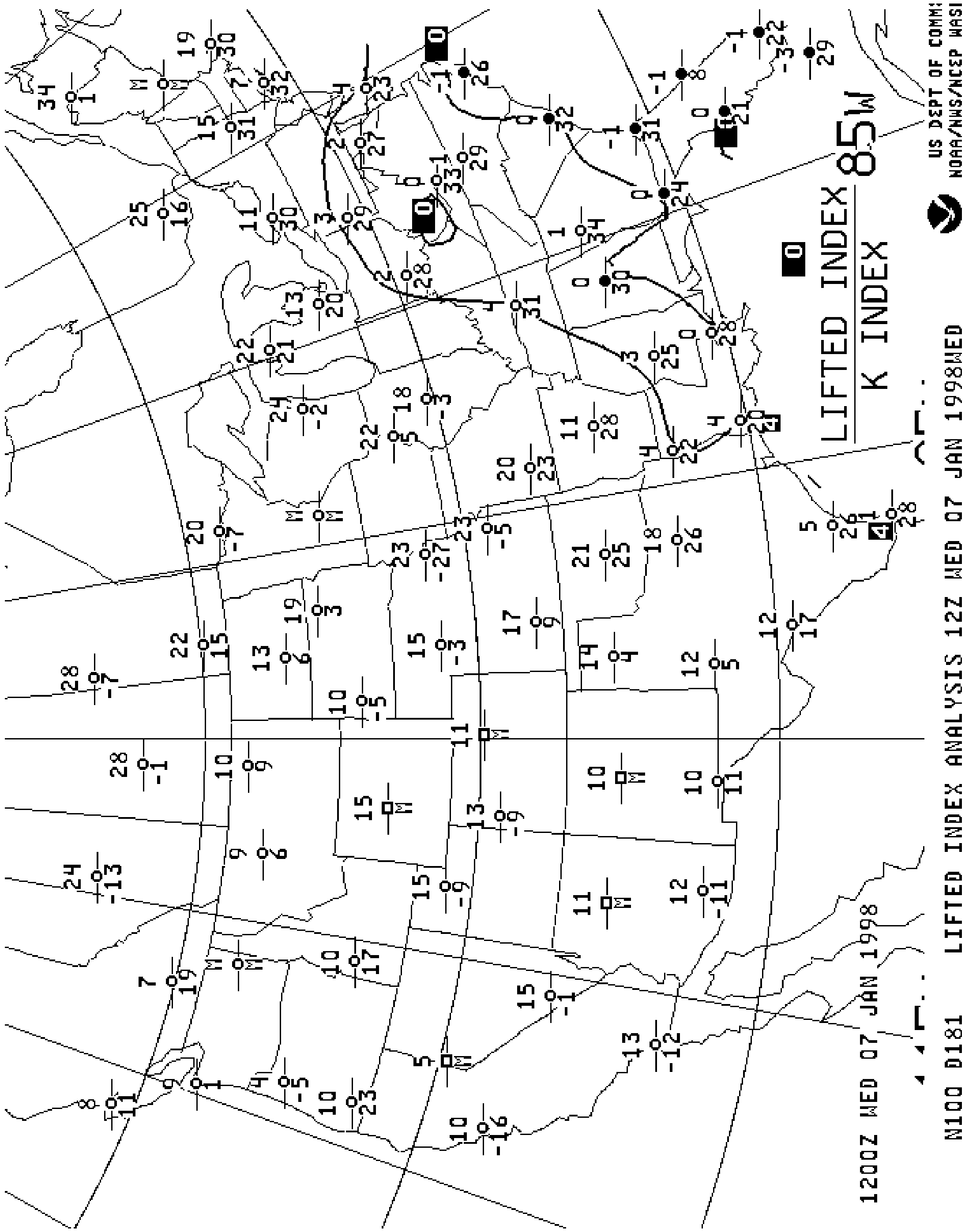


Figure 9-2. Stability Panel.

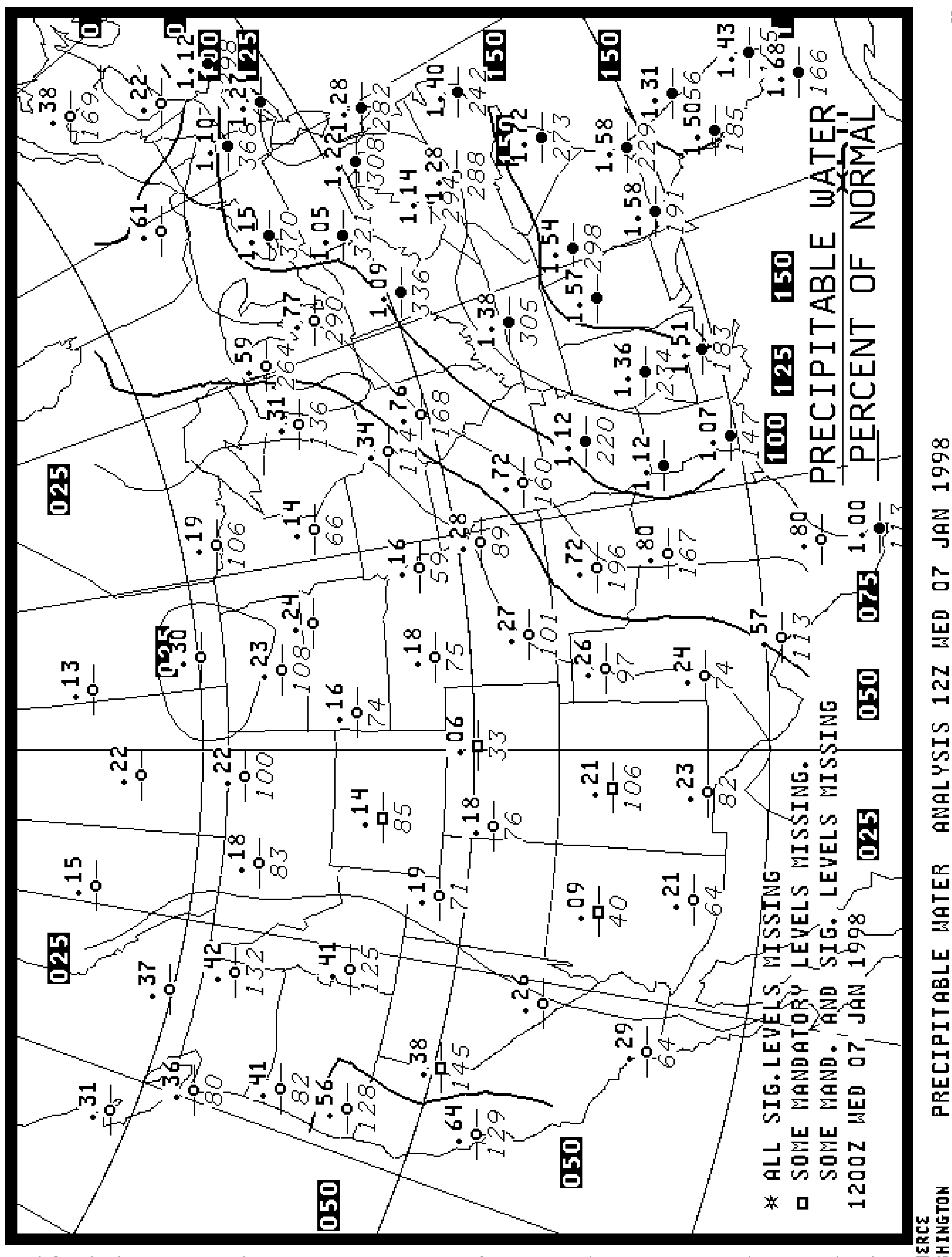


Figure 9-3. Precipitable Water Panel.

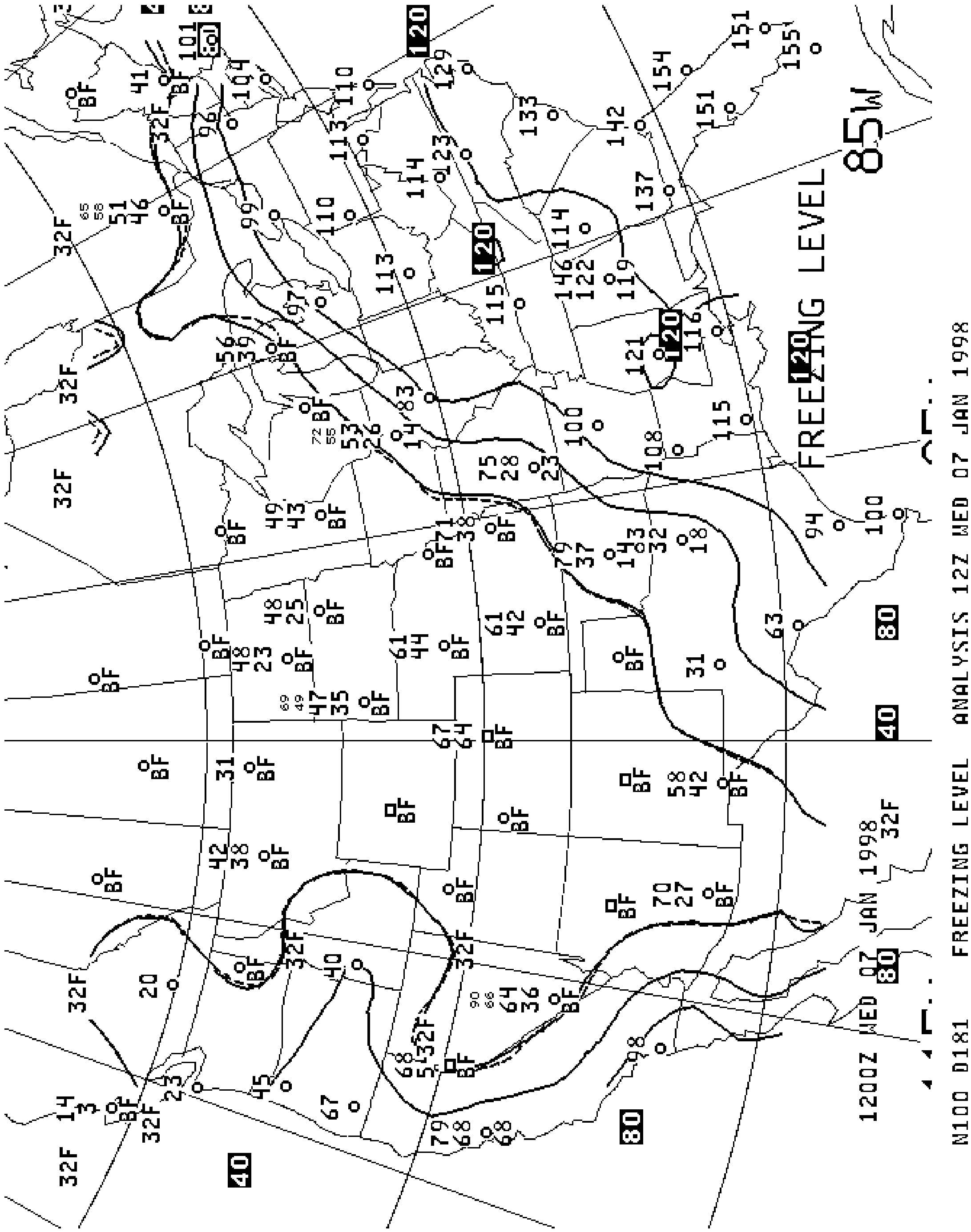


Figure 9-4. Freezing Level Panel.

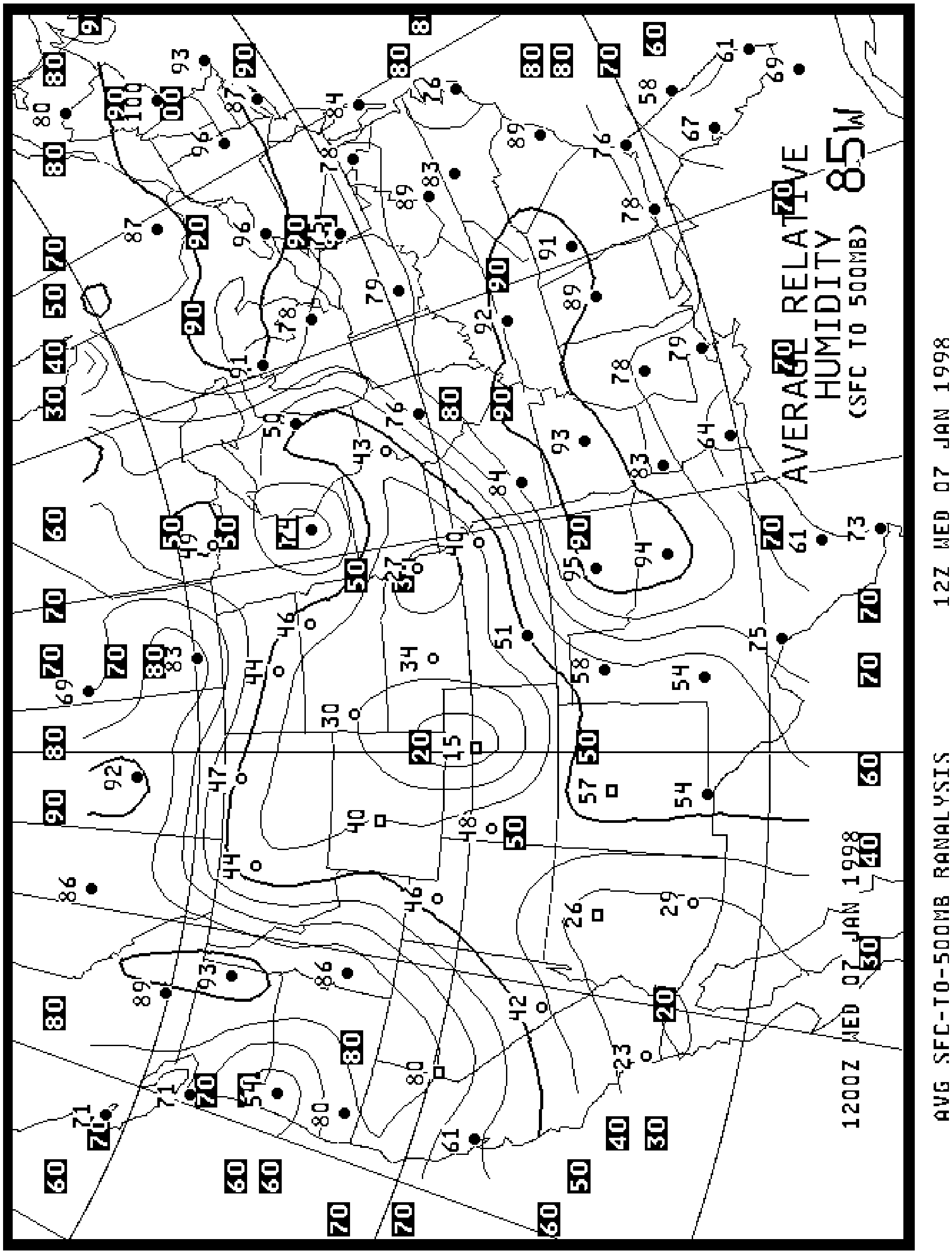


Figure 9-5. Average Relative Humidity Panel.